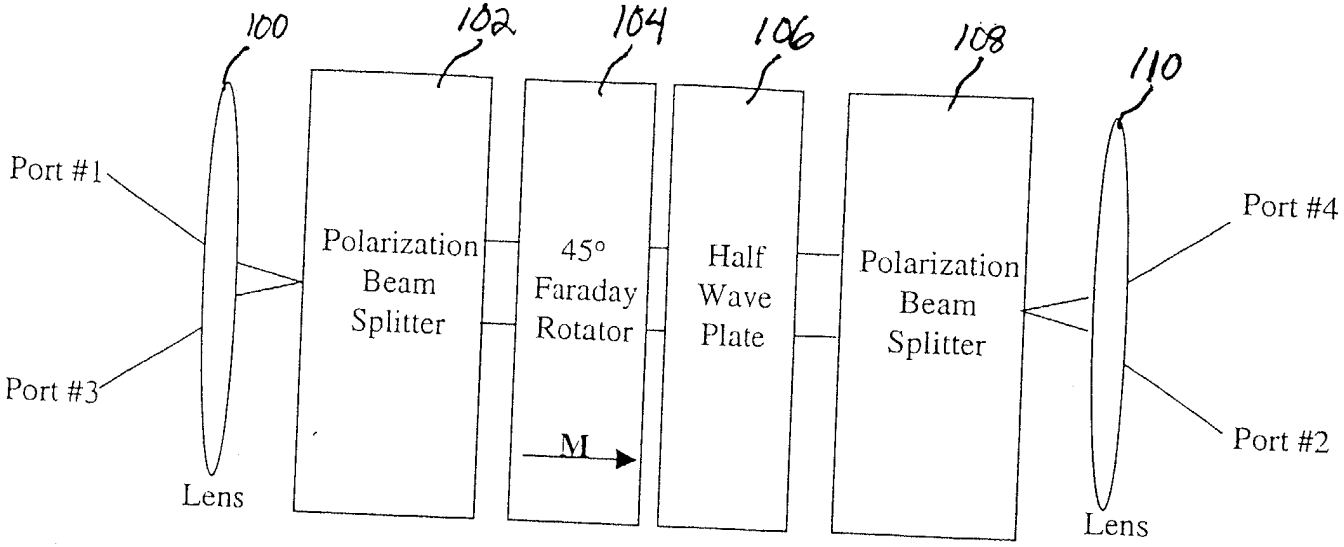
20ZTTO" 96059660

Fig. 1
Prior Art



20211D" 96059660

Fig. 2
Prior Art

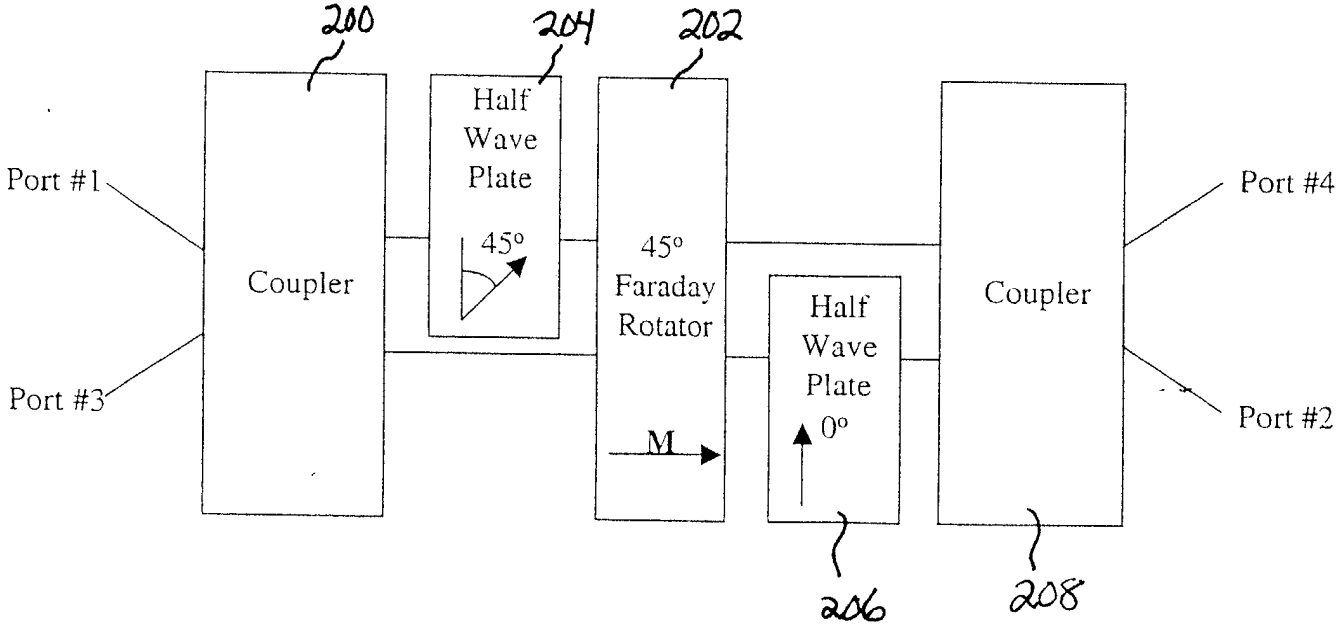
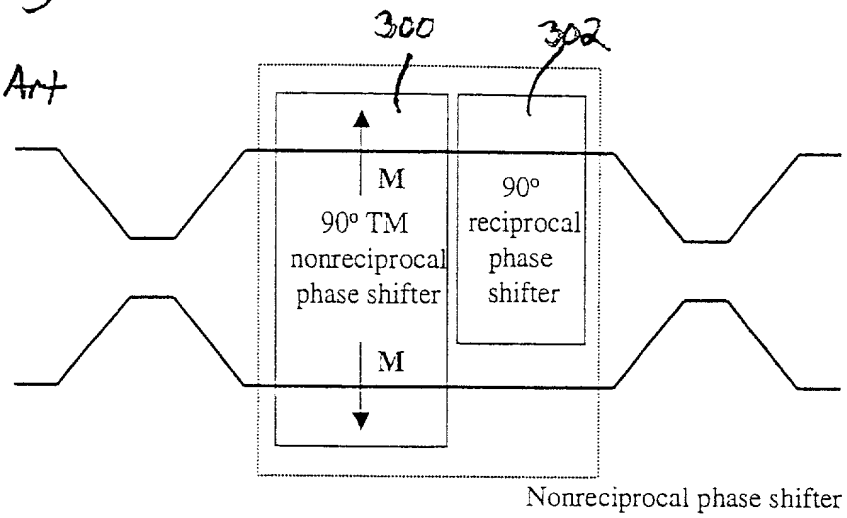


Fig. 3

Prior Art



Nonreciprocal phase shifter

WO 96/39660 PCT/US96/09660

Fig. 4A

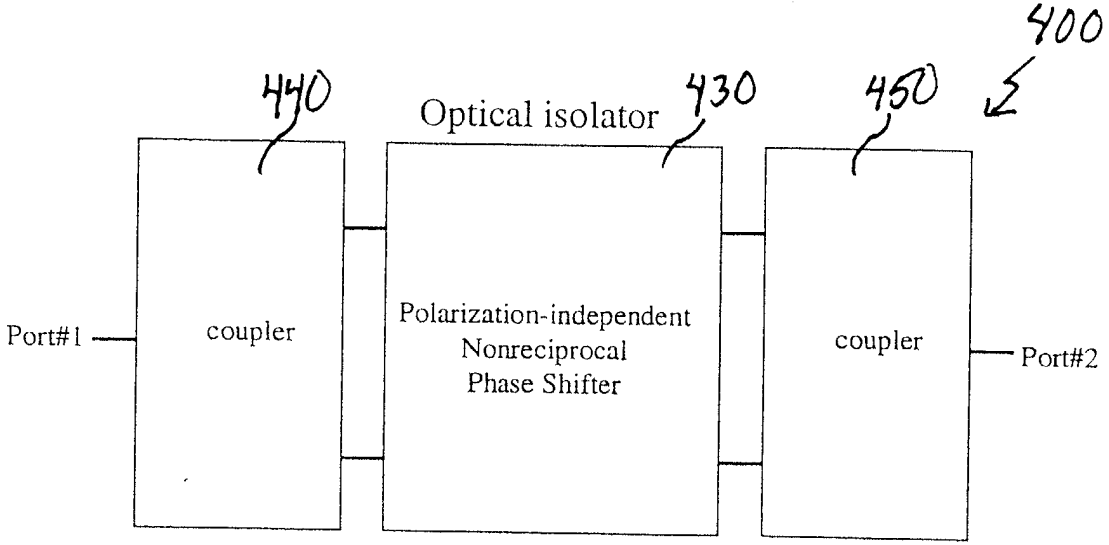
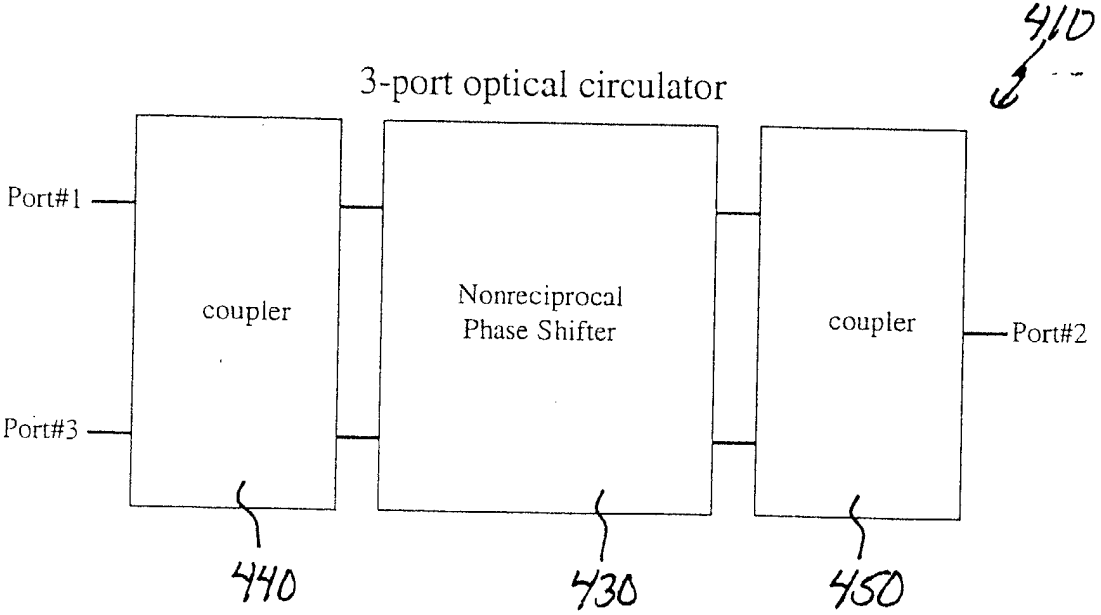


Fig. 4B


410
3-port optical circulator
Port#1
Port#3
coupler
Nonreciprocal
Phase Shifter
coupler
Port#2
440
430
450

20210 "96059660

Fig. 4C

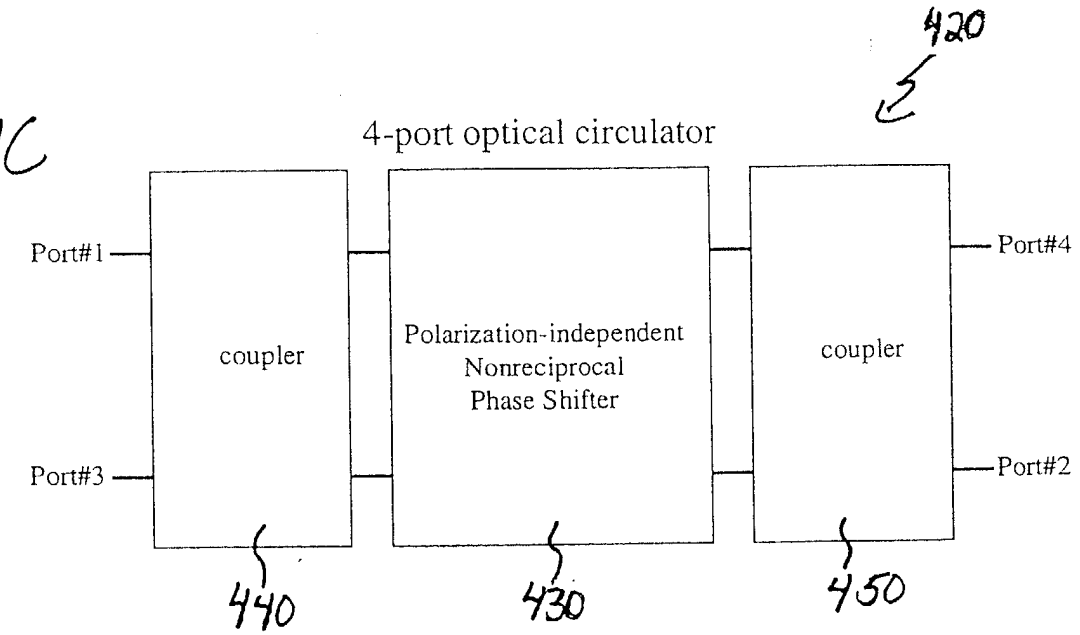


Fig. 5A

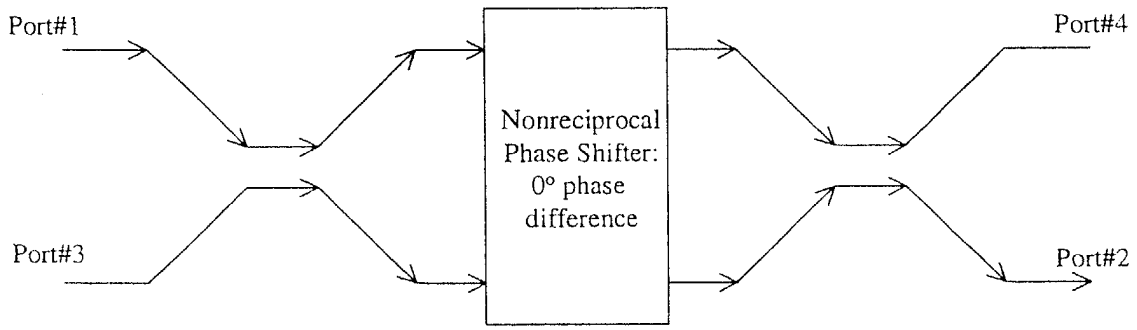

Port#1
Port#3
Nonreciprocal Phase Shifter: 0° phase difference
Port#4
Port#2

Fig. 5B

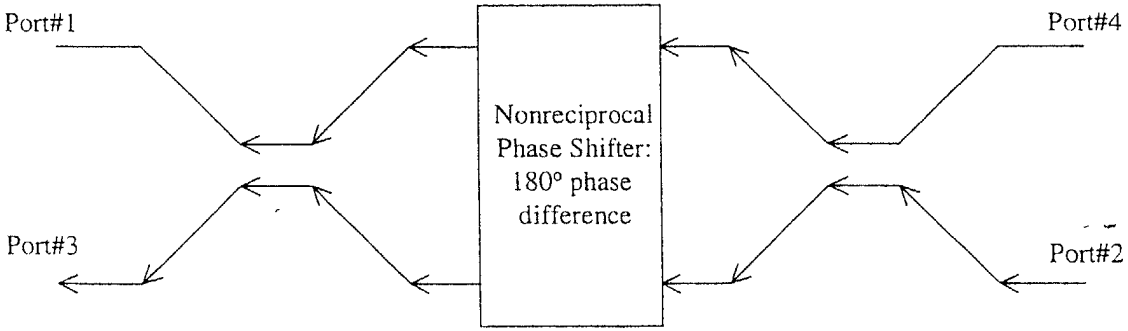

Port#1
Port#3
Nonreciprocal Phase Shifter: 180° phase difference
Port#4
Port#2

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Fig. 6A

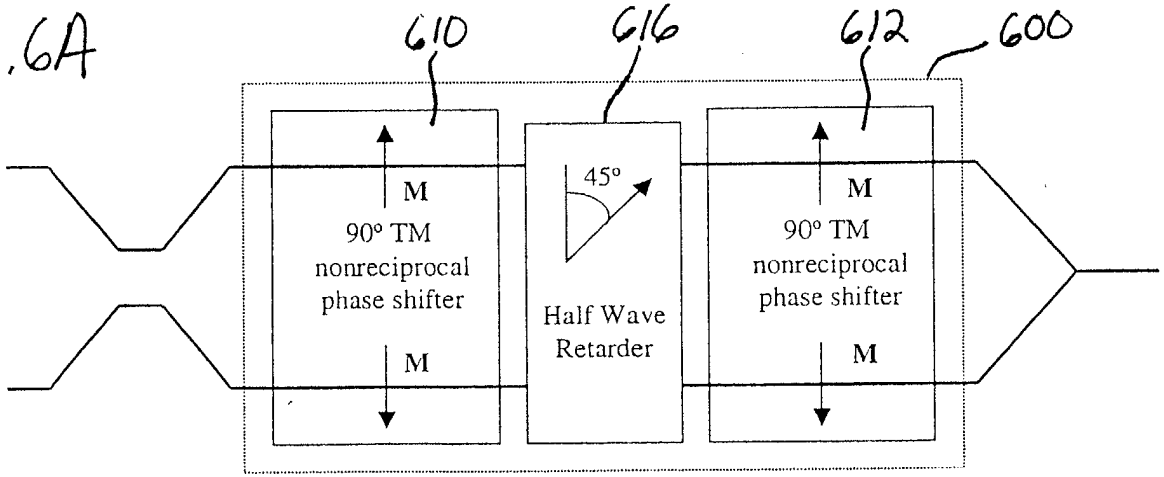


Fig. 6B

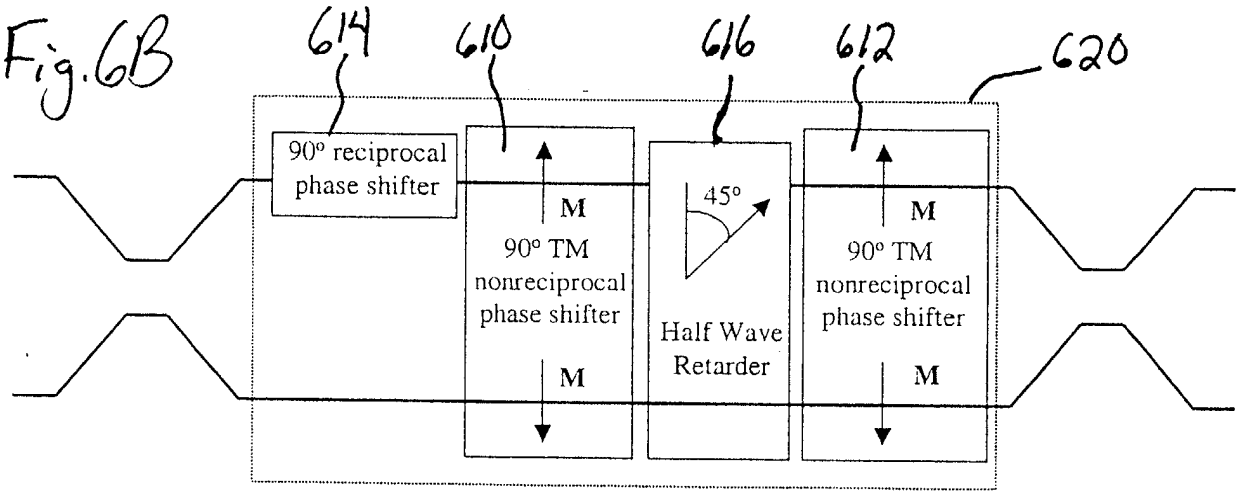

614
610
616
612
620
90° reciprocal phase shifter
M
90° TM nonreciprocal phase shifter
M
45°
Half Wave Retarder
M
90° TM nonreciprocal phase shifter
M

Fig. 6C

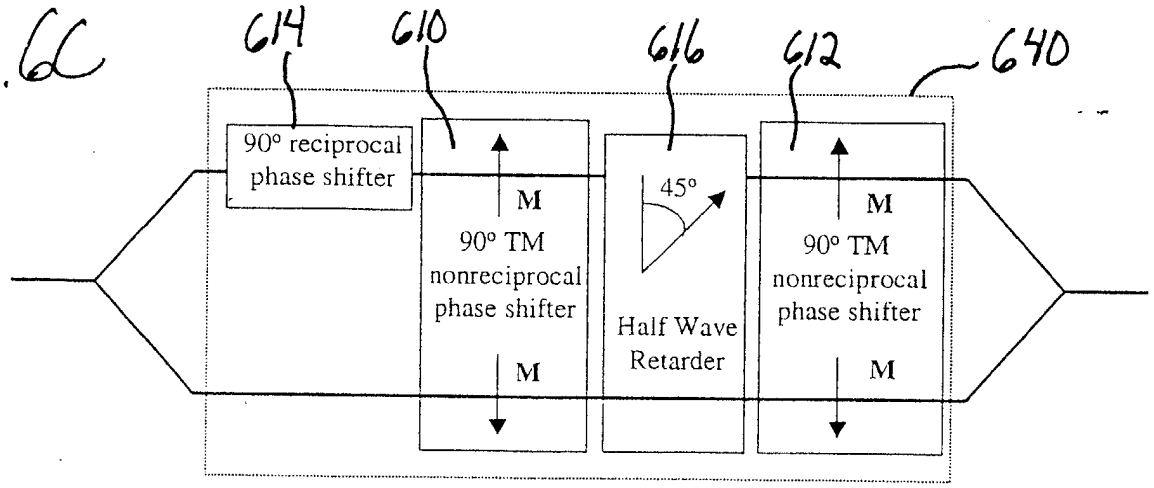
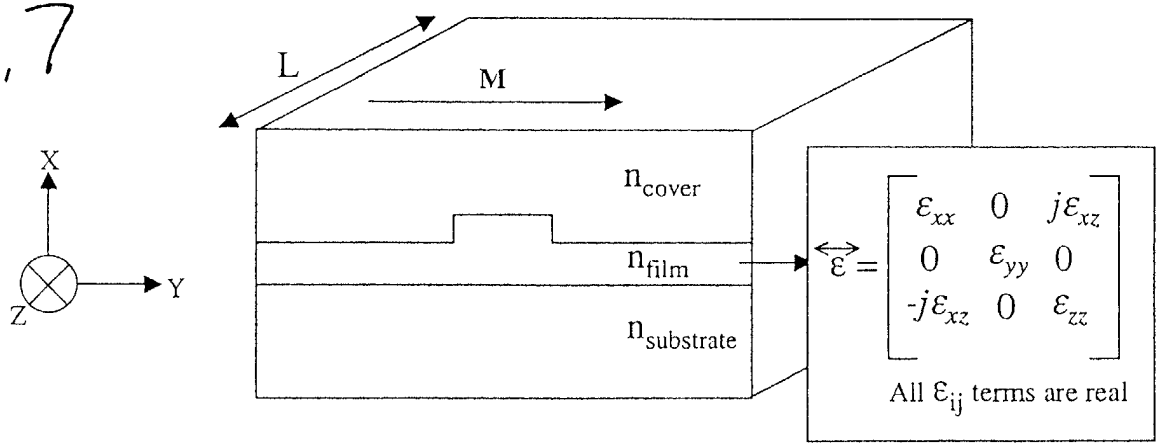

614
610
616
612
640
90° reciprocal phase shifter
M
90° TM nonreciprocal phase shifter
M
45°
Half Wave Retarder
M
90° TM nonreciprocal phase shifter
M

Fig. 7



$$\delta\beta = 2\Delta\beta = j\frac{2\omega\varepsilon_o}{N}\iint E_x^{*}\varepsilon_{xz}E_z\,dxdy$$

E_x, E_z: electric field components
ω: optical frequency
ε_o: dielectric constant in free space
N: power normalization factor

Choose: $\delta\beta \cdot L = 90^{o}$

20CTTO" 96059660

Fig. 8

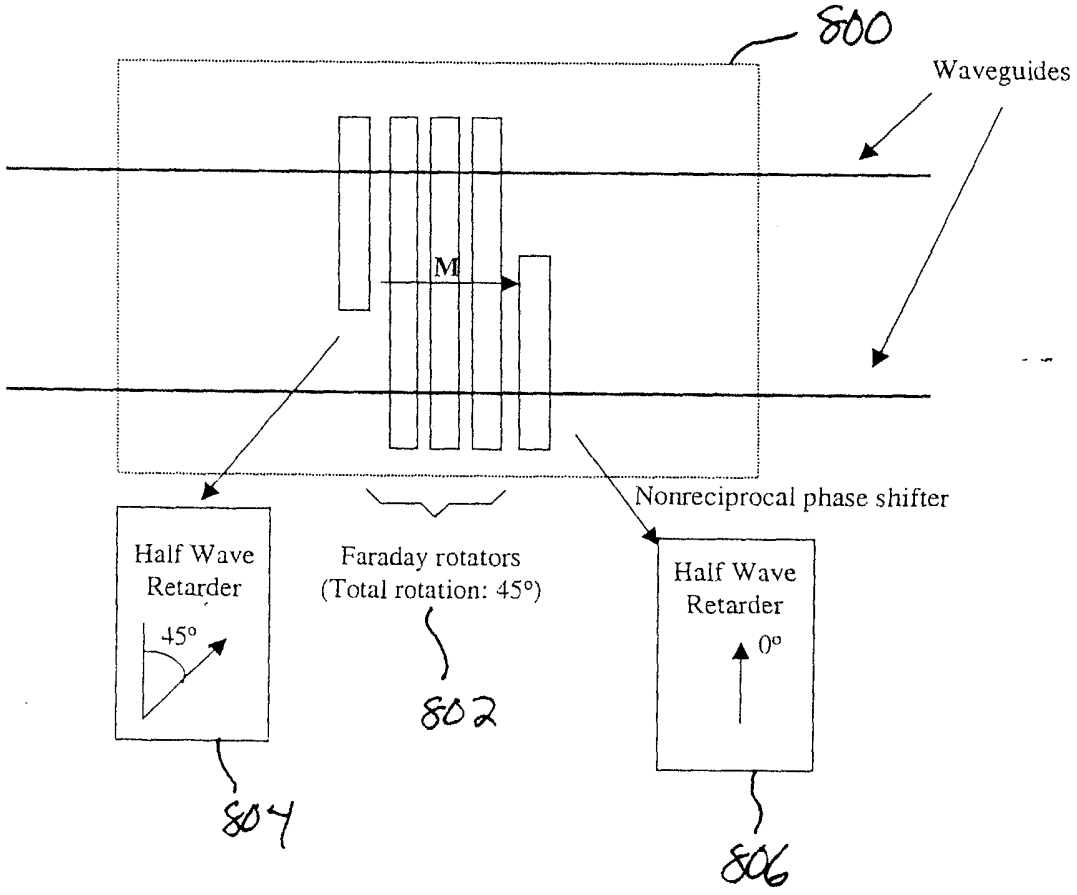


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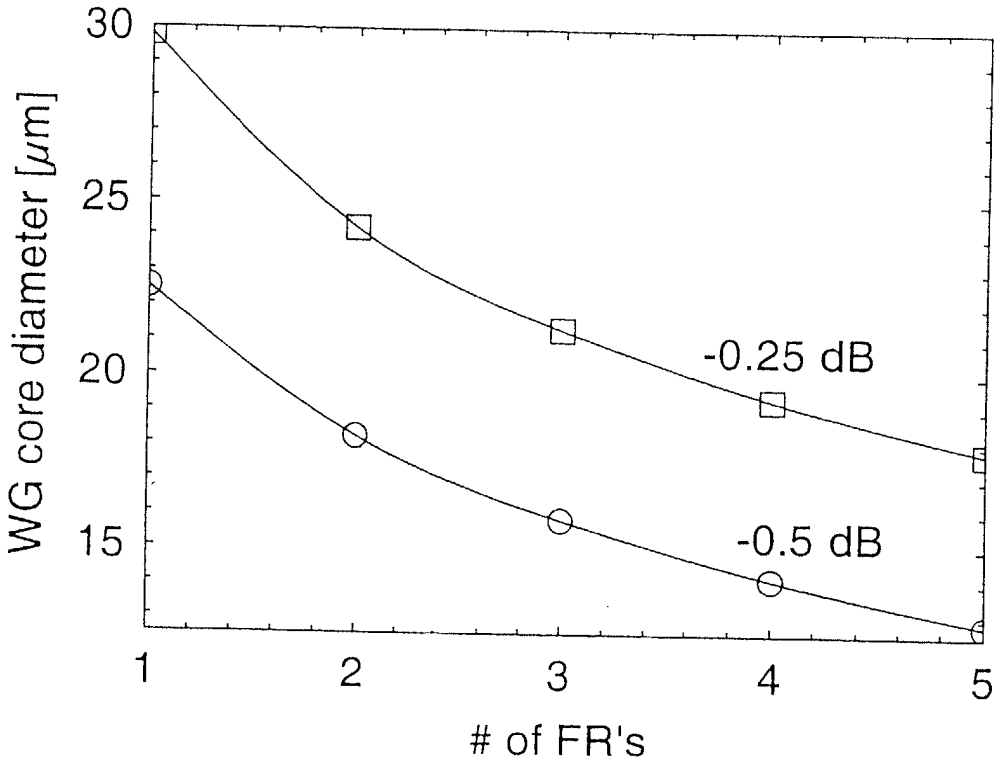
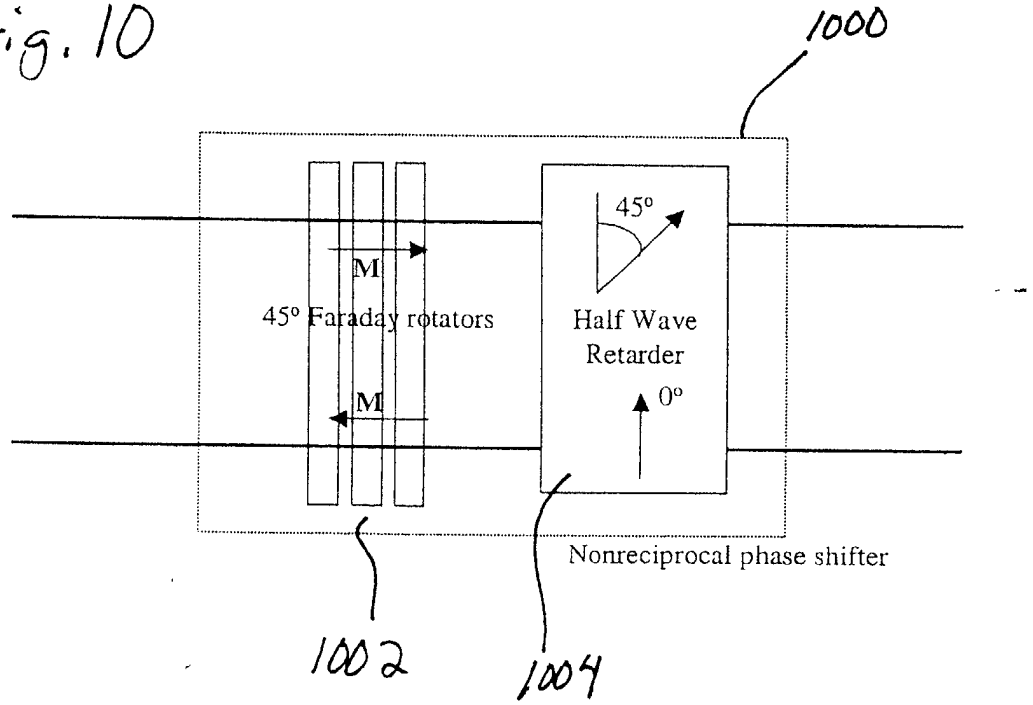
Fig. 9



20CTD" 96059660

Fig. 10



20ZTTD" 96059660

Fig. 11A

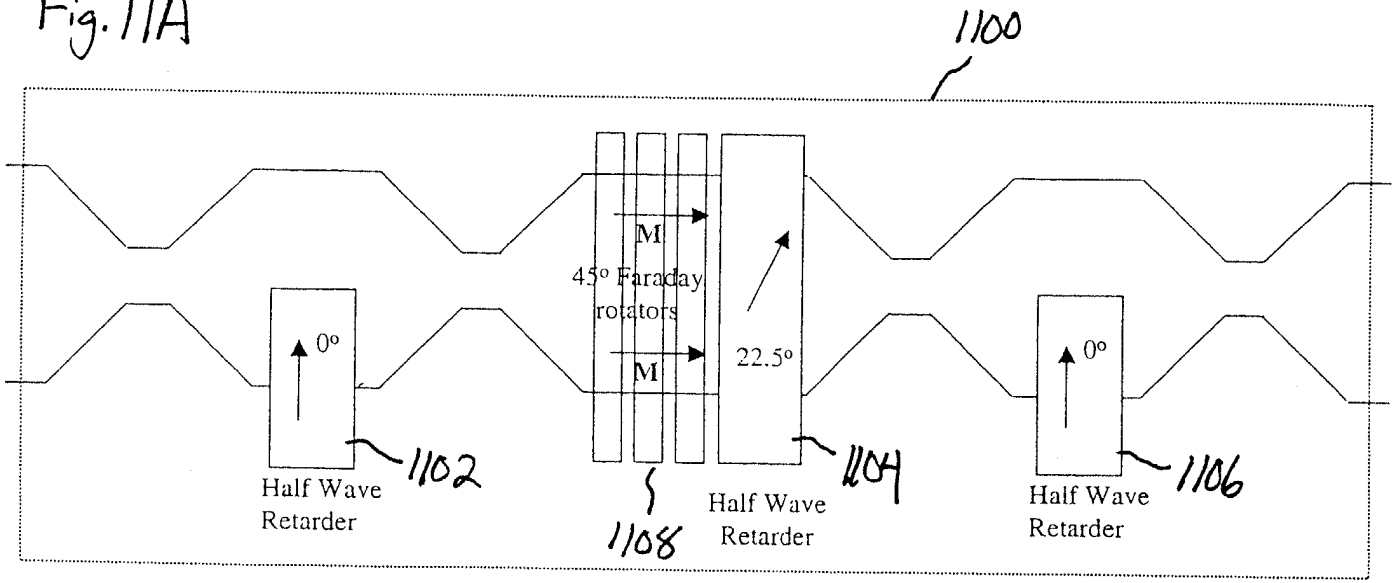


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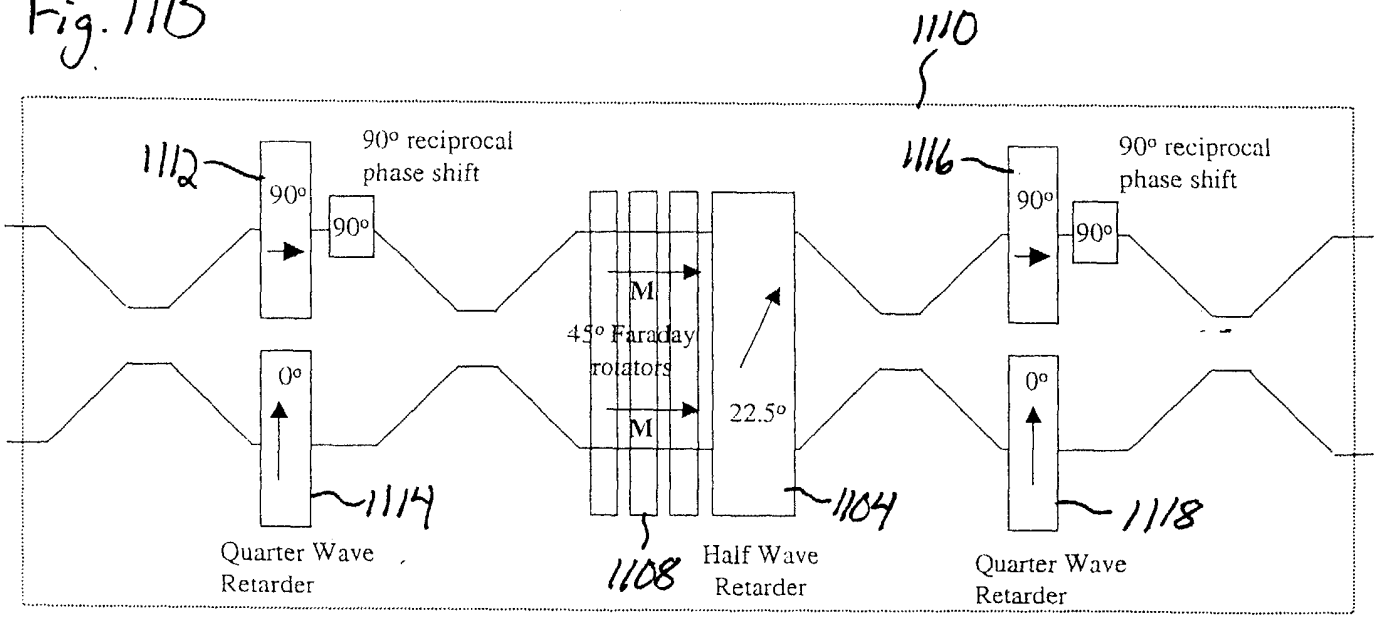
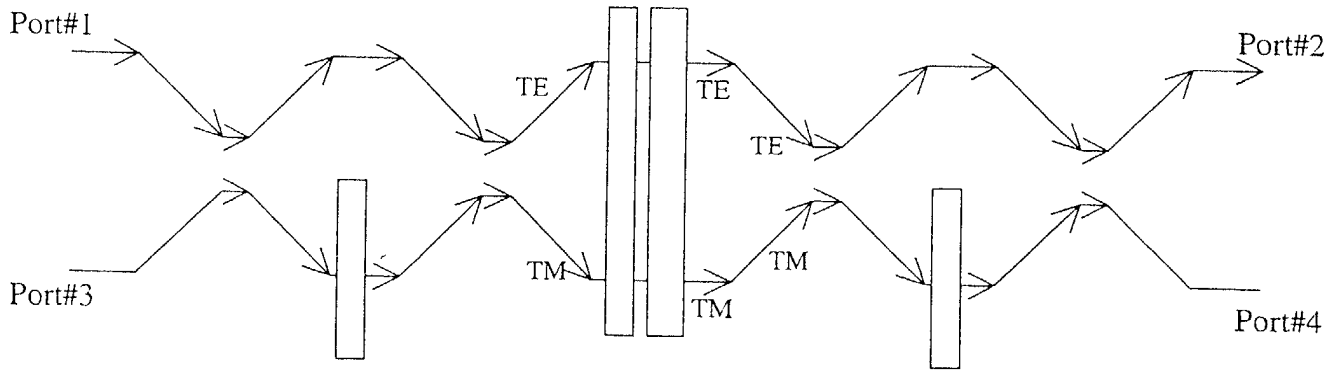
Fig. 11B



20ZTTD" 96059660

Fig. 12A



20/TTD" 96059660

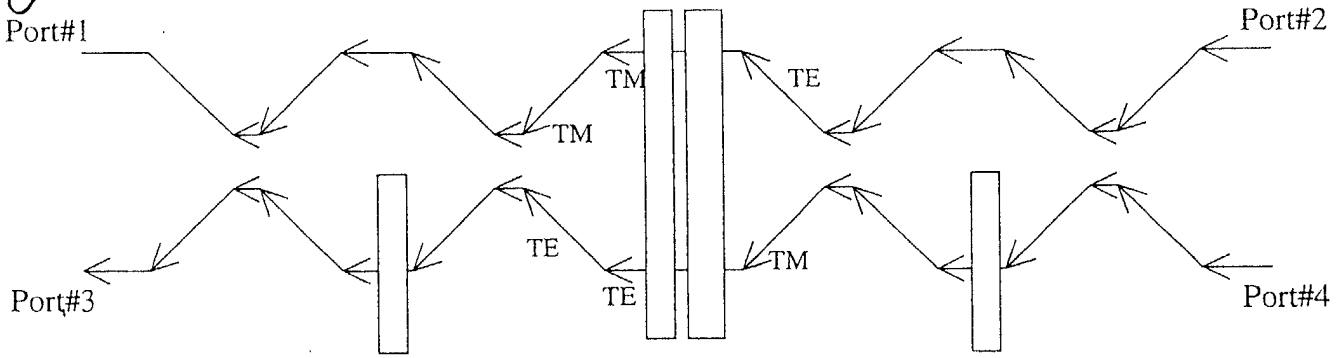



Fig. 12B